REMARKS

In the Office Action, claims 1 and 2 were rejected under 35 USC §103(a) as being unpatentable over Ando et al in view of Kawashima.

Claim 1 has been amended to add the feature that mechanical restraining means is protective bearings which are antifriction bearings and to limit the way the electromagnets are controlled by the electromagnet control means in order to distinguish the present invention over the references.

Comparison Between Present Invention and References (regarding Rejections under USC 103)

(1) Present Invention

The present invention is characterized by the following points.

Mechanical restraining means is protective bearings (touchdown bearings) which are antifriction bearings, and thereby mechanically determines movable ranges of the rotary body in three supporting directions, i.e., an axial direction and two radial directions orthogonal to each other.

Electromagnet control means supplies to each electromagnet a predetermined steady-state current and a control current which varies depending on the position of the rotary body, and magnetically levitates the rotary body at a predetermined

target levitated position by controlling the control current according to the position of the rotary body.

Electromagnet control means calculates a median C of a value A of an integral output when the rotary body is magnetically levitated in the vicinity of one of limit positions and a value B of an integral output when the rotary body is magnetically levitated in the vicinity of the other limit position, and sets the position of the rotary body corresponding to the median C as a target levitated position of the rotary body.

The foregoing constitution enables the present invention to have an advantageous effect so that the rotary body can be magnetically levitated approximately at a mechanical central position.

(2) Ando

First, Ando is different from the present invention in function of the protective bearings.

As stated above, in the present invention, the protective bearings determine the movable ranges of the rotary body in all three supporting directions thereof and protect the electromagnets, the sensors and so forth. On this account, even if the rotary body comes to lose support by the electromagnet control means, there is no fear that the rotary body would collide with and break the electromagnets, the sensors and so forth.

In contrast, in Ando, the protective bearings determine the movable ranges of the rotary body only in two supporting directions thereof, i.e., two radial directions, and protect the electromagnets, the sensors and so forth.

Since Ando's magnetic bearing device is of the so-called horizontal type wherein the rotary body is disposed horizontally and the gravity of the rotary body itself gives no influence on control in the axial direction, the protective bearings protect only in the radial directions and do not protect in the axial direction. This is obvious from FIG. 1 of Ando. As noted from FIG. 1 of Ando, the protective bearing 19 on the right side only restrains the rightward movement of the rotary body 3 in the axial direction and does not restrain the leftward movement of the rotary body 3 in the axial direction. Further, the protective bearing 18 on the left side does not restrain either the rightward or leftward movement of the rotary body. Since there exists a sensor 16 between the annular leftward end face of the rotary body 3 and the protective bearing 18, when the rotary body moves leftward, the above-mentioned end face is brought into contact with the sensor 16 and is not brought into contact with the protective bearing 18. Therefore, the protective bearing 18 cannot restrain the leftward movement of the rotary body 3. Accordingly, since both of the protective bearings 18 and 19 do not restrain the leftward movement of the rotary body 3, those protective bearings 18, 19 do not

restrain the movement with respect to the axial direction and are different from the protective bearings of the present invention which restrain the movable ranges of the rotary body in all three supporting directions. In the case where the magnetic bearing device of Ando is provisionally made to be of the vertical type as described in the embodiment of the present invention, namely when the Ando's device is used with the rotary body disposed vertically, the left side of FIG. 1 comes bottom since the machine tool 21 is usually used with the tool disposed downward. Consequently, the rotary body 3 moves toward the left side of FIG. 1 owing to the gravity of the rotary body itself, collides with and breaks the sensor 16.

Next, Ando is different from the present invention in the way the electromagnets are controlled by the electromagnet control means.

As stated above, in the present invention, when the position of the rotary body is shifted by the external load, the electromagnet control means controls the position of the rotary body by varying the control current and controlling the magnetic force of the electromagnets, and magnetically levitates the rotary body at a predetermined target levitate position.

The Examiner states that Ando also controls the position of the rotary body by applying the steady-state current to the electromagnets. However, since only just applying the

predetermined steady-state current to the electromagnets cannot cause a change in magnetic force of the electromagnets, the position control against the external load cannot be done. In the case of Ando, the external load is varied so that the magnetic force of the electromagnets keeps constant. More specifically stated, as described in Ando, column 4, in or after line 42, Ando varies the feeding speed of the cutting table by controlling the revolution speed of the servo-motor and controls the grinding speed of the machine tool, in other words, controls the external loads on the magnetic bearings. Further, as described in Ando, column 4, in or after line 4, the micro-computer does not control the electromagnets but the revolution speed of the servo-motor. Thus, the magnetic bearing device of Ando is the one used exclusively for the working device and is different from the general magnetic bearing device which needs to control the position of the rotary body against the external load. Furthermore, in the first place there is no technical thought in Ando to control the position of the rotary body by controlling the current applied to the electromagnets.

(3) Kawashima

Kawashima does not have the construction corresponding to the protective bearings of the present invention.

That is, Kawashima's device presupposes that the rotary body is brought into contact with the electromagnets by the electromagnets, and Kawashima does not have the construction of the present invention wherein the protective bearings mechanically determine the movable ranges of the rotary body. Further, since there is no protective bearing in Kawashima, Kawashima can only magnetically levitate the rotary body at a magnetic central position by setting the magnetic central position as the target levitated position, but cannot magnetically levitate the rotary body approximately at the mechanical central position as the present invention can do. Furthermore, since Kawashima does not have bearings, it is unthinkable to combine Kawashima with Ando which has bearings.

Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "Version With Markings To Show Changes Made".

Based on the foregoing amendments and remarks, it is respectfully submitted that the claims in the present application, as they now stand, patentably distinguish over the references cited and applied by the Examiner and are, therefore, in condition for allowance. A Notice of Allowance is in order, and such favorable action and reconsideration are respectfully requested.

However, if after reviewing the above amendments and remarks, the Examiner has any questions or comments, he is cordially invited to contact the undersigned attorneys.

Respectfully submitted,

JACOBSON HOLMAN, PLLC

By: Jonathan L. Scherer Reg No 29,851 for
Allen S. Melser
Reg. No. 27,215

400 Seventh Street, N.W.
Washington, D.C. 20004-2201
(202) 638-6666

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Please amend claims 1 as follows:

1. (Twice Amended) A magnetic bearing device for magnetically levitating a rotary body by contactlessly supporting the body with magnetic attraction of pairs of electromagnets with respect to an axial direction and two radial directions orthogonal to each other and to the axial direction, the rotary body having movable ranges in the three supporting directions determined by mechanical restraining means, the magnetic bearing device comprising: a pair of electromagnets arranged to hold the rotary body at opposite sides thereof in the direction of each of control axes in the respective three supporting directions, means for detecting the position of the rotary body in the direction of the control axis, protective bearings serving as the mechanical restraining means, and electromagnet control means having at least an integral operation unit for controlling the electromagnets based on the result of detection of the position by the position detecting means, wherein the electromagnet control means is to magnetically levitate the rotary body at a predetermined target levitated position by supplying to each electromagnet an energizing current comprising a combination of a predetermined steady-state

current and a control current which varies depending on the position of the rotary body, and the electromagnet control means ~~comprising~~ comprises a target levitated position setting means for setting as ~~a~~ the target levitated position of the rotary body in the direction of the control axis the position of the rotary body corresponding to a median of an integral output which is the output of the integral operation unit when the rotary body is magnetically levitated in a vicinity of one of limit positions in the direction of the control axis determined by the mechanical restraining means and the integral output of the integral operation unit when the rotary body is magnetically levitated in a vicinity of the other limit position.